

Price: \$25 US



# Industrial Fiber Optic Link/Repeaters<sup>®</sup>

Model CH45

## User Manual

UMCH45

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**DYMEC**  **DynaStar**  
NETWORKS FOR INDUSTRY

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## ***Warnings, Cautions, and Notes as Used in this Publication***

### **WARNING**

Warning notices are used in this publication to emphasize that hazardous voltages, currents, or other conditions that could cause personal injury exist in this equipment or may be associated with its use.

In situations where inattention could cause either injury or damage to equipment, a Warning notice is used.

### **CAUTION**

Caution notices are used where equipment malfunction is possible if care is not taken.

### **NOTE**

### **APPLICATION NOTE**

**Notes and Application Notes call attention to information that is especially significant to understanding and operating the equipment.**

This document is based on information available at the time of its publication. While efforts have been made to be accurate, the information contained herein does not purport to cover all details or variations, nor to provide for every possible contingency in connection with installation, operation, or maintenance. DYMEC-DynaStar assumes no obligation of notice to holders of this document with respect to changes subsequently made.

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⑥ Link/Repeater is used exclusively to describe DYMEC-DynaStar's unique family of Fiber Optic Data Links.

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## 1. INTRODUCTION

The DYMEC-DynaStar Model CH45 is a data communication Link/Repeater Card, for use in the DYMEC-DynaStar 3900 Series Chassis, which allows the replacement of copper wire with fiber optic cable. Link/Repeaters simply convert electrical signals to light for transmission, then, when received, convert the light to electrical signals. This is done for EIA 422 and EIA 485 formats.

Link/Repeaters are passive to software protocol. They are not addressable by communication protocols and do not provide any control logic capability supporting communication protocols. Link/Repeaters are designed with several features that allow easy installation and flexibility in configuring for various communication systems.

One should read all of this manual to fully understand how to use the many features of the Link/Repeaters in an effective communication system.

### 1.1 DEFINITIONS

The following terms are used in this manual:

**IED:**

An IED is any intelligent electrical device capable of EIA 422 and/or EIA 485 data communication, such as; a computer, RTU, PLC, "smart" meter, relay, etc. The IED must have resident software or firmware that manages the data communication logic, including protocol (formatting and timing), addressing capability (if required), control logic software "handshaking", and scheduling.

**Point-to-Point Configuration:**

Two Link/Repeaters connected directly to each other.

**Master/Slave Loop Configuration:**

More than two Link/Repeaters connected together where the FOC connects the T optical port of one device to the R optical port of the next unit in the loop. One IED is designated as the Master and controls all the communication and the other IEDs act as Slaves and respond only when specifically polled by the Master.

**Peer-to-Peer Loop Configuration:**

More than two Link/Repeaters connected together where the FOC connects the T optical port of one device to the R optical port of the next unit in the loop. Each IED has the capability of becoming loop Master as allowed by the controlling software. Not Supported by the CH45.

**Echo:**

The return of the Master's transmission back to the Master after traveling around the optical loop.

**Optical Bus Configuration:**

More than two Link/Repeaters connected together in a "linear" topology and there is no returning echo of a transmission.

**Optical Star Configuration:**

More than two Link/Repeaters connected together in a "Hub and Spoke" topology and there is no returning echo of a transmission.

**Master:**

The Master is the IED which controls the network in a Master/Slave configuration. This IED is responsible for the control of the network, the polling of the Slaves for information, and the prevention of data collisions. In a loop configuration, the Master's communication is echoed back to and stops at the Master. The Master's mode Jumpers are always in the "OFF" position.

**Slave:**

A Slave is an IED that is passive in a Master/Slave configuration. A Slave's communication is under the control of the Master, and the slave only responds to specific poll requests from the Master.

**Peer:**

Peers are IEDs that have equal status and each may initiate a communication when allowed by the system software by a time slot, token, etc.

**FOC:**

Fiber Optic Cable.

**Single-mode:**

Single-mode fibers generally have diameters of 5µm to 13µm. Because of this small core, only one axial path for light propagation is available through the fiber. The optics required to drive single-mode fiber have to be highly focused so that minimum dispersion occurs. Though requiring more expensive optic emitters, the benefit is that longer transmission distances (~30 km) can be achieved.

**Multi-mode:**

Multi-mode fibers have core diameters of 50µm and larger. This larger core allows the light rays to be propagated along several different paths down the fiber. The different paths include an axial component as well as reflected components. Multi-mode units are economical and effective for transmission over distances up to 5 km.

**Mode Jumpers:**

The mode Jumpers enables (ON) or disables (OFF) the repeater function of the Link/Repeater.

**HD / FD Jumpers:**

These Jumpers adapt the Link/Repeater to accept independent transmit and receive channels (4 wire normally associated with EIA 422) or a shared transmit/receive channel (2 wire, generally EIA 485). **(Note the HD / FD Jumpers consists of four Jumpers and all must be set.)**

**Data Coupling Jumper:**

These Jumpers adapt the Link/Repeater for either DC or AC electrical input data coupling. With AC data coupling, the minimum input data rate is 1200 baud. With DC data coupling there is no minimum input data rate, but a signal stuck high on the input will lock up a loop, bussed or star network.

**Logic Invert Jumper:**

This Jumper adapts the Link/Repeater for connecting to DYMEC-DynaStar Models 5844/5845 and/or RS232 IED's or to provide for an off quiescent state for the LED's in a loop when biasing pulls the inputs to an "on" state.

**Biasing Resistor Jumpers:**

This jumper allows the Link/Repeater to easily adapt the device input bias resistors to reduce the loading from 330 Ohms to 10 K Ohms.

**Simplex Communication:**

Transmit only or receive only communications.

**Half Duplex Communication:**

Sequential transmit and receive communications.

**Full Duplex Communication:**

Simultaneous transmit and receive communications.

**T:**

Transmit optical port.

**TE:**

Diagnostic LED that illuminates when the Link/Repeater is receiving an electrical transmit from its IED.

**TO:**

Diagnostic LED that illuminates when the Link/Repeater is transmitting a signal optically.

**R:**

Receive optical port.

**RE:**

Diagnostic LED that illuminates when the Link/Repeater is delivering a received optical signal electrically to the IED.

**RO:**

Diagnostic LED that illuminates when the Link/Repeater is receiving a signal optically.

**Optical Budget:**

The optical budget is expressed in dB and is the amount of light loss tolerated for communication. The total distance between two devices that a signal can be transmitted is determined by subtracting all the losses of the optical circuit from the optical budget. Various factors in the optical circuit attenuate the light transmission and must be accounted for to assure a reliable optical circuit. Key factors include cable attenuation (expressed as dB per unit length), cable aging, and cable fittings (terminations, splices, splitters, etc.).

**Non Return to Zero (NRZ):**

This type of encoding scheme does not require the voltage potential of each data bit to return to the zero potential. No clock or timing recovery is provided with this type of communication except in the start and stop bits usually found on each data word.

**Return to Zero (RZ):**

This type of encoding scheme requires the voltage potential of each data bit to return to the zero potential. This allows timing recovery with each bit instead of just the start and stop bits of the data word.

**Number of Repeats:**

The Number of Repeats is the number of Link/Repeaters that may be connected in a network when the Repeat function is required such as in loop configurations. The sum of Slaves in a Master/Slave loop is the number of repeats for that type of loop. The number of Peers minus one is the number of repeats in a Peer-to-Peer loop.

**Asynchronous Communication:**

This type of communication does not transmit a separate clock signal with the data signal. Link/Repeaters support asynchronous communication only. A communication scheme where the clock needs to be transmitted (Synchronous Communication) is not supported unless the clock is embedded with the data.

## 1.2 MODEL CH45 LINK/REPEATERS

Each Link/Repeater consists of the following elements shown in Figure 1.

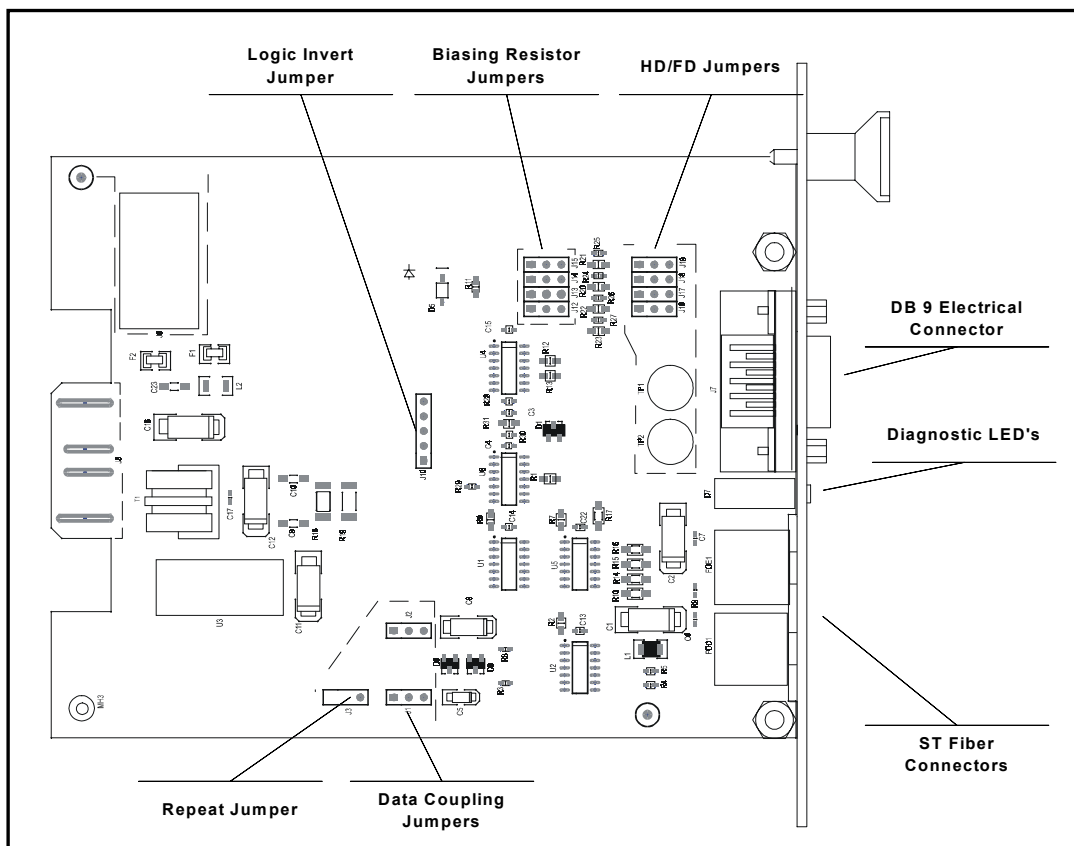


FIGURE 1. Elements of the Link/Repeater

### 1.2.1 9 pin Data Port D-connector

The Link/Repeater connects directly to an IED's EIA 422 or 485 communication port. The pin out configuration of the Link/Repeater is shown in Figure 2. If the IED's port is not a 9 pin D-connector or if the IED's pin out configuration differs, an adapter is required. (See Figure 4 for Factory Default Settings of All Jumpers)

### 1.2.2 HD/FD Jumpers

The HD/FD Jumpers adapt the Link/Repeater to accept independent transmit and receive channels or a single shared transmit/receive channel. **(All 4 jumpers must be set.)**

**HD:** In this position, the Link/Repeater accepts a shared transmit/receive communication channel such as normally associated with EIA 485 2 wire standards. When in the HD position, the Link/Repeater is "listening" for data signals both optically and electrically and automatically configures to the correct state. This position is normally used for EIA 485 2 wire connections and only half-duplex or simplex communication is available. Multi-drop networks may be either Peer-to- Peer or Master / Slave.

**FD:** When independent transmit and receive electrical channels are available, select the FD position. This will normally be used for EIA 422 or EIA 485 4 wire standards. The Link/Repeater can support full duplex, half duplex or simplex communication in this position. Multi-drop networks may only be Master/Slave.

HD MODE	HD↑ FD↑	FD MODE	HD↓ FD↓
• 1	Trans/Rec Data – [B/B']	• 1	Transmitted Data – [B] (Link Input)
• 2	Trans/Rec Data + [A/A']	• 2	Transmitted Data + [A] (Link Input)
• 3	No Connect	• 3	Received Data – [B'] (Link Output)
• 4	No Connect	• 4	Received Data + [A'] (Link Output)
• 5	Signal Ground	• 5	Signal Ground
• 6	No Connect	• 6	No Connect
• 7	No Connect	• 7	No Connect
• 8	No Connect	• 8	No Connect
• 9	Chassis Ground	• 9	Chassis Ground

FIGURE 2. Data Port Pin Assignments

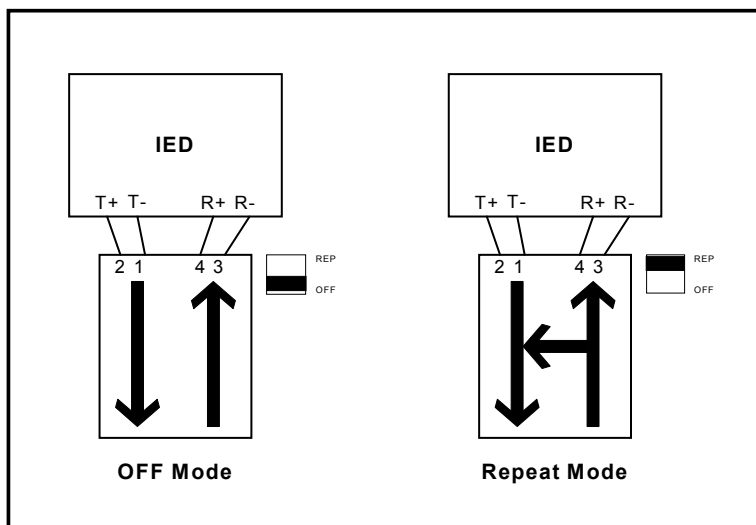


FIGURE 3. Data Signal Path

### 1.2.3 Mode Jumpers

The Mode Jumpers enable the repeater function in the "ON" position and disables it in the "OFF" position. Note Figure 3 for data path.

**ON:** The repeater function available in the Link/Repeater is enabled. This function converts the optical signal received on the R optical port to an electrical signal and delivers this signal to the appropriate pins of the 9 pin connector, as well as, re-transmits the signal optically out the Link/Repeater's T optical port.

**OFF:** The repeater function available in the Link/Repeater is disabled. The Link/Repeater converts the optical signal received on the R optical port to an electrical signal and delivers this signal to the appropriate pin of the 9 pin connector, and does not re-transmit the signal optically out the Link/Repeater's T optical port.

### 1.2.4 Data Coupling Jumper

The Data Coupling jumper selects the electrical input conditioning; the AC position selects capacitively coupled, the DC position is directly coupled.

**AC:** AC coupling has a minimum incoming data requirement of 1200 baud due to the capacitive coupling. This option blocks DC electrical levels should the device connected fail and 'stick in a high level'.

**DC:** DC coupling allows DC logic levels to be transmitted over the fiber network, care must be taken to guarantee that when any device stops transmitting packets that the input level returns to a state that allows the T receptacle (emitter) to turn off. If it does not and the IED is part of a loop, bussed or star network, the first device to transmit blocks all other devices on the network from transmitting.

### 1.2.5 Biasing Resistor Jumpers

The Biasing resistor jumpers select the electrical input biasing. Biasing on RS422/485 inputs provides the ability for the inputs to a device (the Link/Repeater) to be in a known electrical state if the outputs that are connected to it go into a Tri-State (non driving) condition. Pins marked B or - are pulled to +5 volts and pins marked A or + are pulled to Signal Ground. The default for the biasing resistors is 330 Ohms, optionally 10K Ohms can be selected.

**Normal:** 330 Ohm Biasing resistors. This is equivalent to 9 loads when configuring a bus network configuration.

**10K Ohms:** 10K Ohm biasing resistors. This is the equivalent to 1 load when configuring a bus network. This setting should be used on at least one Link/Repeater if there are 2 or more electrically connected.

### 1.2.6 Logic Inversion Jumper

The Logic Inversion Jumper is located on the Link/Repeater. Use of this feature is required when optically interconnecting IEDs using RS-232 to IEDs using EIA 422 or 485 or IEDs that have biasing that pulls the "A" (+) line high and the "B" (-) line low during the quiescent state. (Refer to Section 3.5)

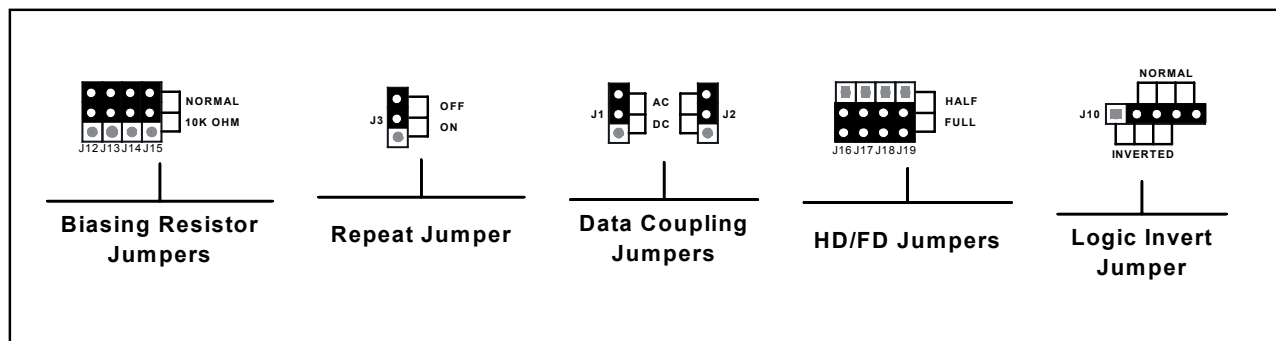
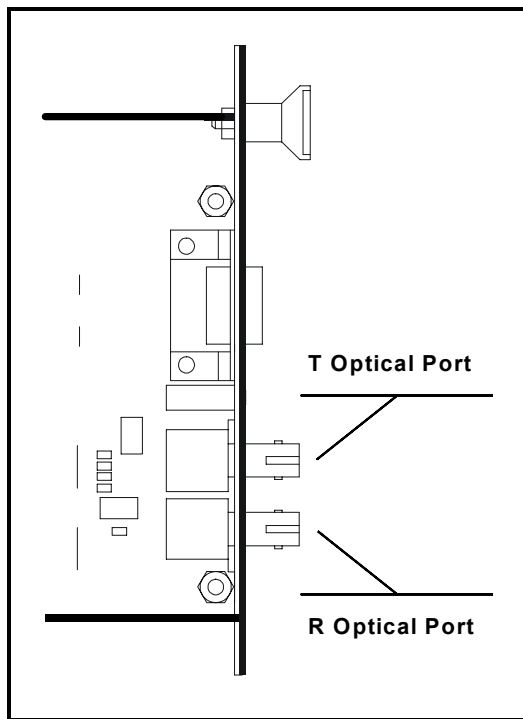


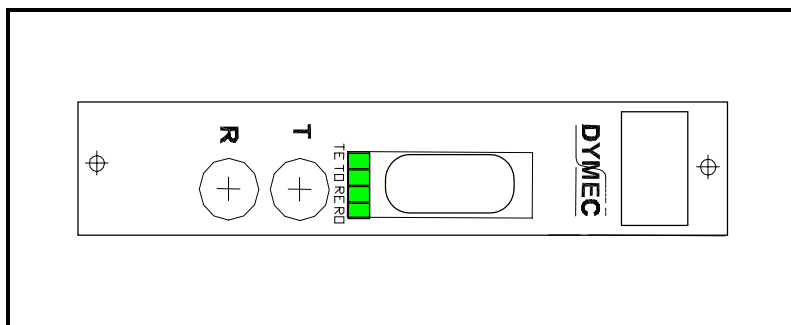
FIGURE 4. Jumpers Settings (Factory Default Settings)



**FIGURE 5. Optical Ports**

### 1.2.7 Optical Ports

There are two optical ports, T and R. The T optical port transmits data signals optically to the next Link/Repeater. The R port receives the optical data signal from another Link/Repeater's T optical port. Each port is fitted with an "ST" type receptacle for connecting the FOC

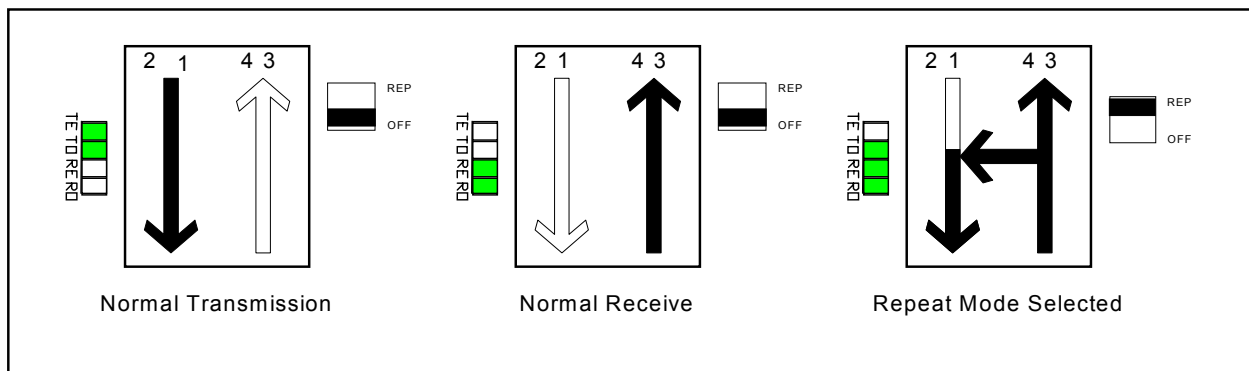


**FIGURE 6. Diagnostic LED positions on faceplate of CH45**

### 1.2.8 Diagnostic LEDs

Each Link/Repeater is equipped with four green diagnostic LEDs (See Figure 6). They represent the electrical transmit (TE), optical transmit (TO), electrical receive (RE), and optical receive (RO) paths. These LEDs, when illuminated, show that the appropriate path is active. When the Link/Repeater is transmitting, both TE and TO LEDs will illuminate to show the transmit path active. When the Link/Repeater is receiving light signals, both RO and RE LEDs will illuminate. If the unit is in the repeat mode and receiving light, the RO, RE and TO LEDs will illuminate because the signal is being re-transmitted out the optical port, as well as, being delivered to the D-connector. LEDs only illuminate when the path is active; powering of the unit does not illuminate these LEDs unless their path is active. When data is present on the paths, the LEDs may "flicker"; this is normal. The diagnostic LEDs may be used for trouble shooting by observing

that the illumination of the LEDs corresponds with activity in the unit. See Figure 7 for LED patterns and signal paths.



**FIGURE 7. Diagnostic LED patterns and signal paths**

#### NOTE

The diagnostic LEDs only illuminate when there is signal traffic and are not illuminated during signal "quiet" times. If during quiet time, TE and TO are illuminated, it suggests either a polarity reversal (pin 2 with pin 1) or that the IED is biased pulling the "A" (+) line with respect to the "B" (-) line. After checking the polarity on the connections, refer to Section 3.5.

The diagnostic LEDs may "flicker" when data is passing. This is normal operation.

### 1.2.9 Power Connections

Model CH45 is powered through a blade connector when inserted in the DYMEC-DynaStar 3900 15 slot Chassis: Model CH45 has an internal DC/DC converter that isolates the system and earth ground from signal ground on the DB9 Connector. Care must be taken when cabling not to short these together as the SWC capabilities will be compromised.

### 1.2.10 Peripheral Equipment

#### 1.2.10.1 IED

An IED is any intelligent electrical device such as: a computer, RTU, PLC, "smart" meter, relay, etc., that has the ability to communicate data via EIA 422 or EIA 485 format. The IED should have a communication port for the connection of the Link/Repeater. If the IED's communication port connector does not accept the Link/Repeater to be plugged in directly, an adapter must be made to accommodate the connection. Care should be taken to assure that the correct signals are connected to each other. See Figure 2 for the Link/Repeater's pin signal assignments. Check your IED's equipment manual for its signal assignments.

The IED must also have intelligent software to execute the data communication. This intelligence needs to logically manage the data and signal traffic, including any addressing, token passing, "handshaking", data formatting and scheduling.

#### 1.2.10.2 Fiber Optic Cable (FOC)

The selection of the fiber optic cable is important. High quality cable can assure the maximum performance of your Link/Repeater. Important factors to consider are the

manufacturer's specification on attenuation per unit length, attenuation due to aging, diameter, and tensile strength. Choosing the best quality FOC for your installation is important.

#### NOTE

**DYMEC-DynaStar can supply multi-mode glass FOC in either Simplex, Duplex, or Breakout construction, cut to length, terminated, polished and tested. The specifications for all DYMEC-DynaStar supplied cables are as follows:**

<b>Fiber Diameter:</b>	<b>62.5/125<math>\mu</math>m</b>
<b>Tensile Strength:</b>	<b>100 kpsi</b>
<b>Loss:</b>	<b>3 dB per kilometer</b>
<b>Aging Loss:</b>	<b>less than 3 dB</b>

The Model CH45 Link/Repeater's optical ports are designed for ST type terminations and are compatible with multi-mode FOC ranging from 50  $\mu$ m to 200  $\mu$ m.

## 2. CONFIGURATIONS, OPERATION, AND INSTALLATION

Model CH45 Link/Repeaters can be connected in a Point-to-Point configuration, an Optical Bus network, an Optical Star network, or a Master/Slave Loop configuration depending on the needs of the overall communication system.

Model CH45 is designed to accept differential electrical inputs per EIA 422 and EIA 485 standards. Various implementation of these electrical standards can result in different types of electrical circuits. The EIA 422 standard and the EIA 485 4 wire standard are normally associated with independent and separate transmit and receive channels. In multi-drop networks, These standards allow Master / Slave operation only.

The EIA 485 2 wire standard generally uses a bi-directional, shared transmit/receive channel. In multi-drop networks, either Peer-to-Peer or Master / Slave operation is possible. The HD/FD Jumpers on each Model CH45 configures the Link/Repeater to accept either condition.

When the HD/FD Jumpers are in the HD position, the Link/Repeater operates in half duplex mode only and both transmit and receive signals share pins 2 (A) and 1 (B).

In the FD position, Link/Repeater pins 2 (A) and 1 (B) connect to the IED's transmit channel. Link/Repeater pins 4 (A') and 3 (B') connect to the IED's receive channel.

### NOTE

**Some IEDs use "+" and "-" labels for their signals. A and A' are "+" and B and B' are "-".**

It is possible to optically connect Link/Repeaters together which are connected to IEDs with different electrical formats, i.e. EIA 422, EIA 485 4 wire and EIA 485 2 wire. It is also possible to optically interconnect Model CH45 to DYMEC-DynaStar Models CH43, 5843 and 5844 which are connected to IEDs operating RS 232 or TTL formats. See section 3.5.

### APPLICATION NOTE

**DYMEC-DynaStar Models 5843, 5844, 5845, 5846, CH43 and CH45 can optically communicate with each other, eliminating the need for format translation interfaces, provided all connected devices are operating at the same data rate and using the same protocol. (Refer to Section 3.5).**

### 2.1 POINT-TO-POINT CONFIGURATION

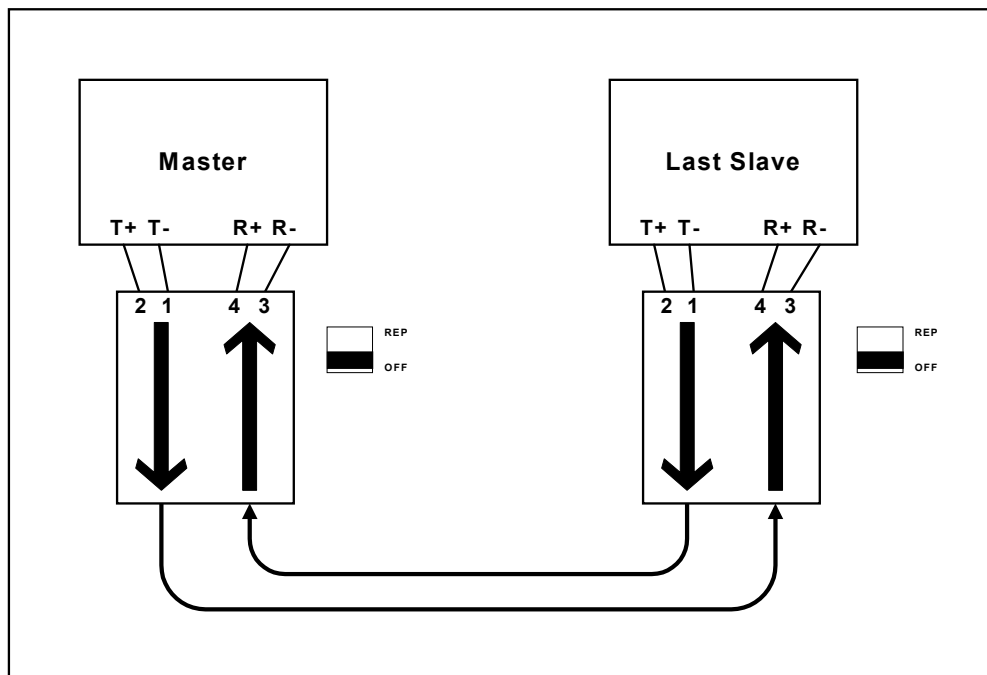
For Point-to-Point operation, two Link/Repeaters are optically connected to each other (see Figure 8). The HD/FD Jumpers are set to the position that satisfies the IED that is connected to the Link/Repeater.

This configuration permits half duplex communication (sequential transmitting and receiving) and simplex (transmitting or receiving only) when the HD/FD Jumpers are in either position. Full duplex is only available for circuits with independent transmit and receive channels where the HD/FD Jumpers are placed in the FD position.

### APPLICATION NOTE

**In Point-to-Point operation, the communication logic (control software) of the IEDs must manage:**

- 1) **The transmission of data signals.**
- 2) **The receipt of data signals.**
- 3) **Any "handshaking" required must be accomplished through software.**



**FIGURE 8. Point-to-Point Configuration**

### 2.1.1 Installation

1. Set the HD/FD Jumper to the appropriate position for each Link/Repeater and its respective IED.
2. Set the Mode Jumper on both of the units to the "OFF" position.
3. Set the Data Coupling Jumpers for the appropriate position based on the data rate used in the communication network
4. Set the Logic Inversion Jumper to the appropriate position based on the communication network
5. Insert the CH45 into an open slot in the 3900 Chassis and then energize the power source to the 3900 Chassis (See the Installation Sheet for the 3900 Chassis for powering Instructions). The Link/Repeater Card is now powered.
6. Connect the Link/Repeater to the IED's RS-232 communication port (including any adapter that may be needed).
7. Connect the Fiber Optic Cables (T of one device to R of the second device).
8. The units are now installed and operating.
9. Verify operation using the diagnostic LEDs. (See Figure 7).

### **WARNING**

When installing a Model CH45 Link/Repeater, an earth Ground must be attached to the Ground Stud on the rear of the case of the 3900 Chassis before connecting to power. Failure to follow this procedure may result in electrical shock to personnel.

## NOTE

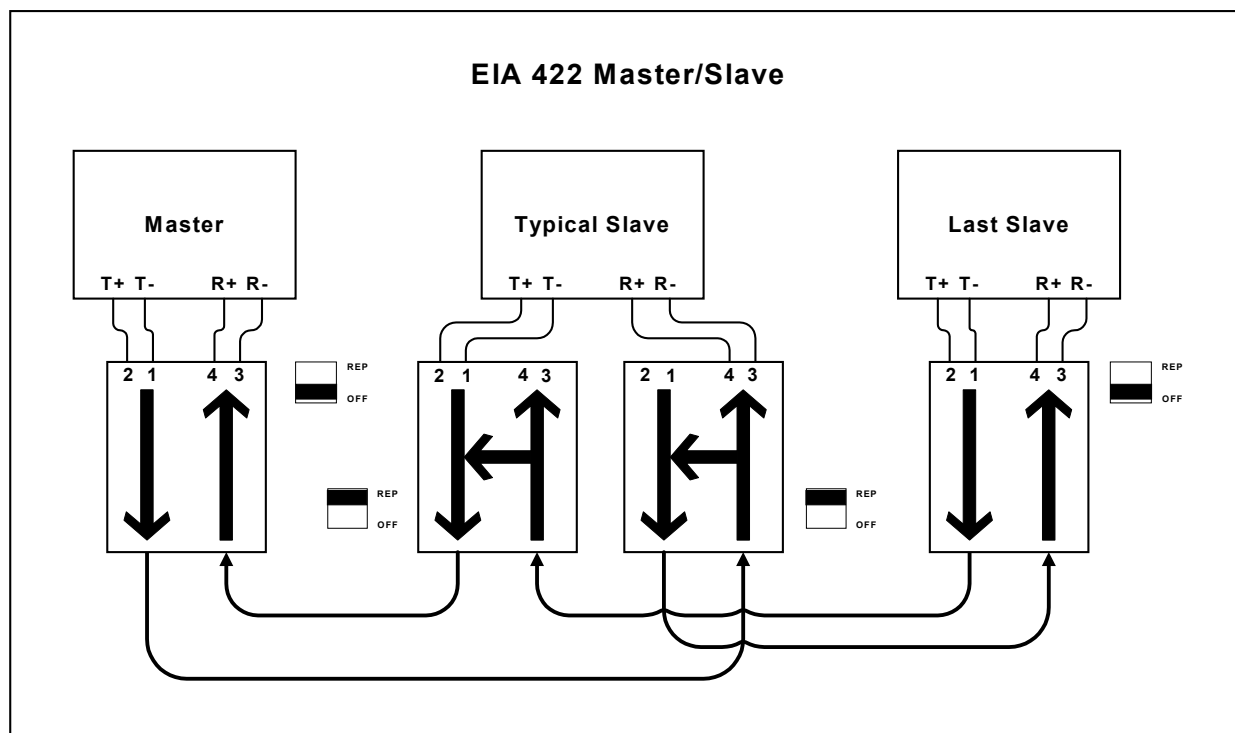
The diagnostic LEDs only illuminate when there is signal traffic and are not illuminated during signal "quiet" times. If during quiet time, TE and TO are illuminated, it suggests either a polarity reversal (pin 2 with pin 1) or that the IED is biased pulling the "A" (+) line with respect to the "B" (-) line. After checking the polarity on the connections, refer to Section 3.5.

The diagnostic LEDs may "flicker" when data is passing. This is normal operation.

## APPLICATION NOTE

The Point-to-Point concept can be used to create an "optical bus" network. This can be useful for those situations where the software in the Master has not been written in such a way that it can handle the return of the transmitted echo that occurs in loop networks.

Figure 9 shows the connections for a Master/Slave EIA 422 "optical bus". Note that EIA 422 Standards do not permit multiple transmitters to be connected together as the outputs can not be tri-stated. In this configuration, all Slaves hear the Master's transmission, but only the Master hears the response from the addressed slave. The Master must always be the first IED in the network.



**FIGURE 9. EIA 422 Bus Configuration**

Figure 10 depicts an EIA 485 multiple drop "optical bus" for both 4 wire and 2 wire systems. The 4 wire system is a Master/ Slave configuration. All the Slaves hear the Master's poll, but only the Master can hear the addressed Slave's response and the Master must be the first IED in the network. However, in the 2 wire configuration, the system is capable of operating as Peer to Peer or Master/Slave. All IEDs hear all communications and the Master may be located at any point in the network.

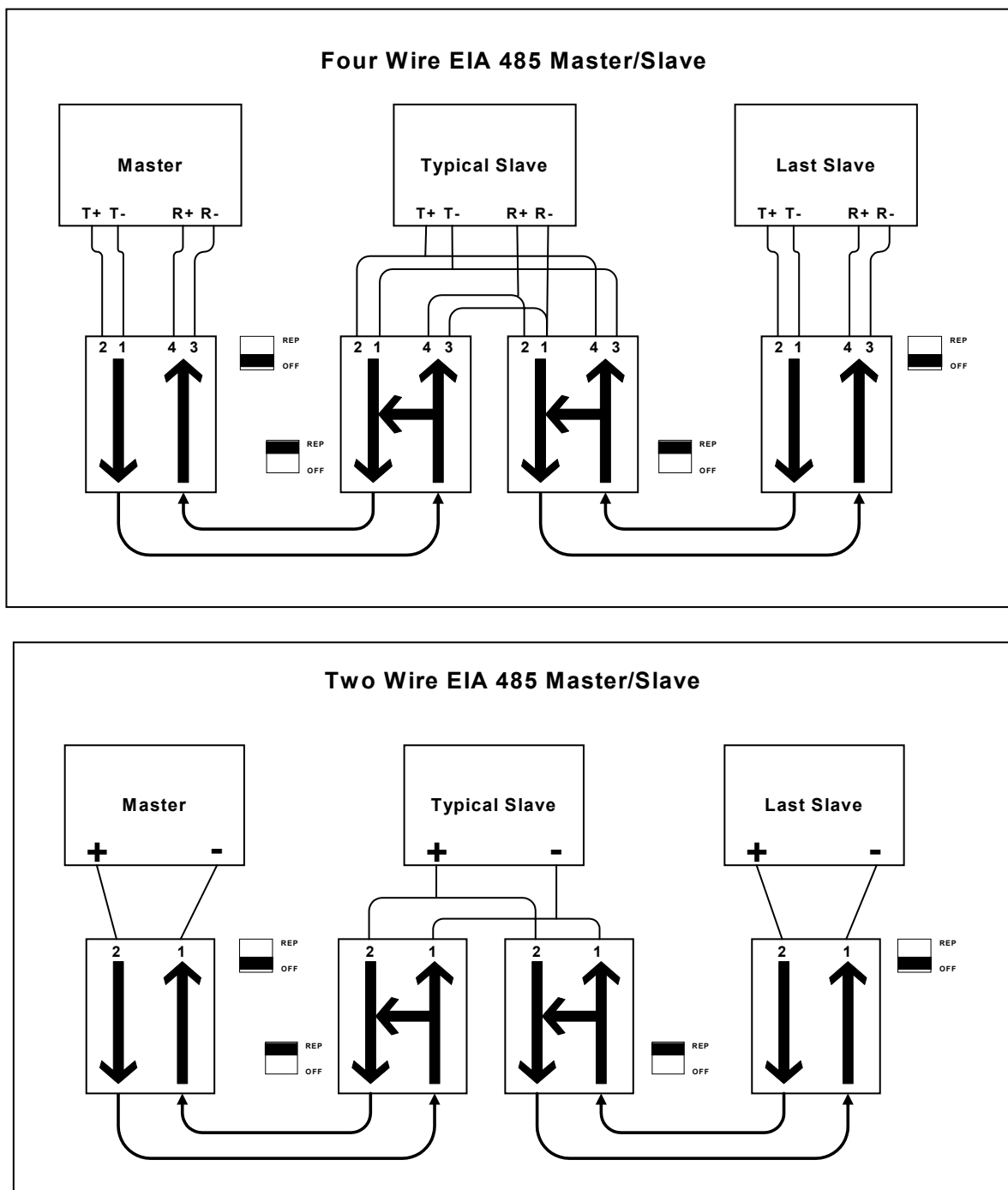


Figure 10. EIA 485 Bus Configurations

#### APPLICATION NOTE

Another variation of the point-to-point concept, is the Optical Star network. This topology may be created using the DYMEC-DynaStar Optical Star OS5 or OS9. This topology creates a "Hub and Spoke" configuration which can be useful in solving a network configuration based upon the physical positioning of the nodes.

**The DYMEC-DynaStar Optical Stars can also be used to create a multi-drop Master / Slave Optical Star network. The Model CH45 is optically compatible with the OS5 and OS9 Master and Slave ports. Figure 11 shows a typical connection of an Optical Star network.**

The master IED must always be connected to the Master port (port 1) of the Optical Star. The slave IED's must always be connected to the Slave ports (port 2 and up) of the Optical Star.

Variations of this configuration are as follows:

The optical star may be the last node of an optical bus configuration. One may create an Optical Bus configuration starting with the Master IED to a series of Slave IEDs and then connect the fiber network to the Master port of the OS5 or OS9 to continue the network in a "Hub and Spoke" topology.

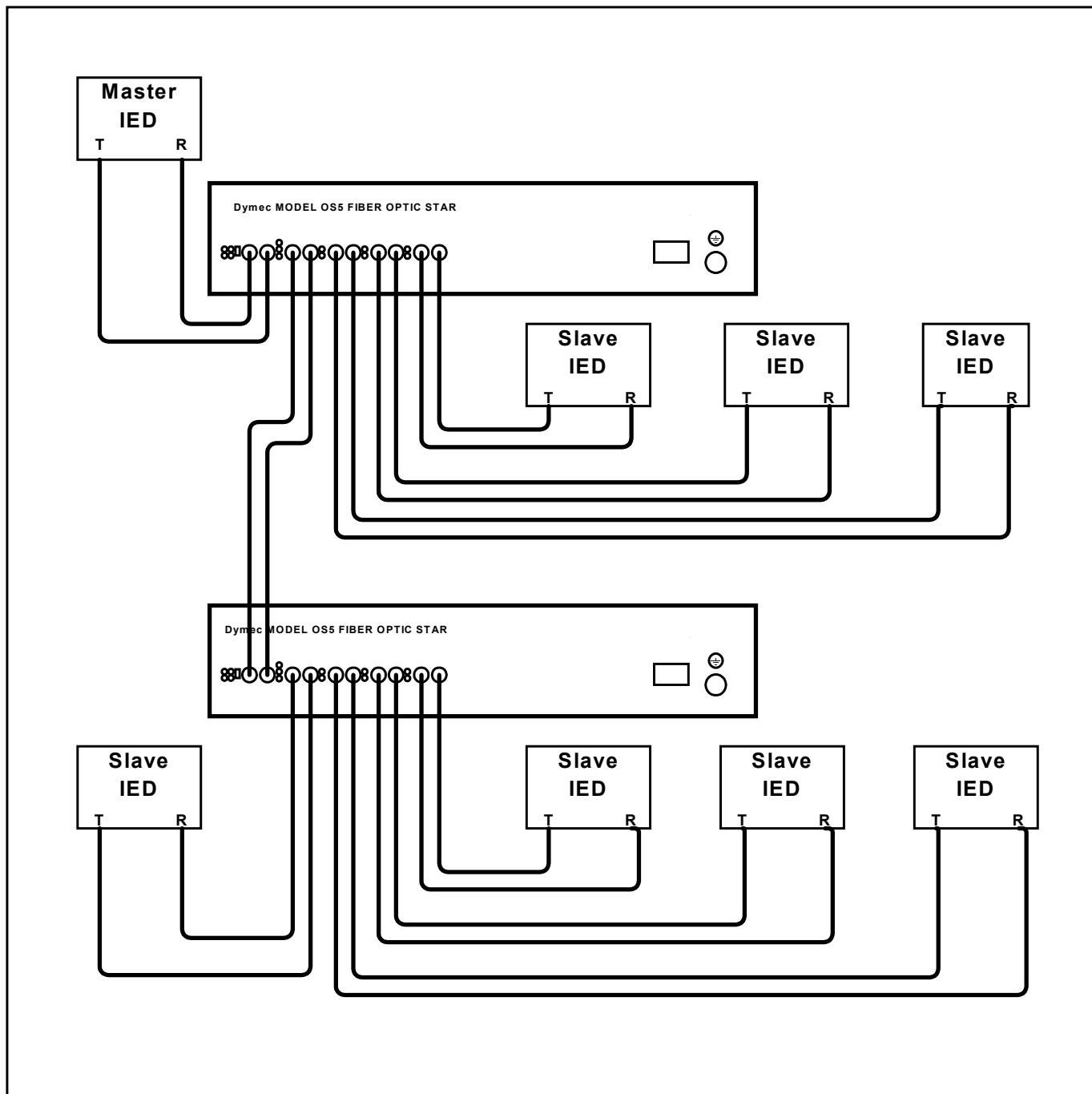
A Master IED may be connected to the master port of an OS5 or OS9 and then an Optical Bus network may be created from any Slave Port of the Optical Star.

The Optical Stars may be "cascaded". Cascading means optically connecting a Slave Port of one Optical Star to the Master Port of the next Optical Star.

IEDs of different electrical formats (i.e., RS-232, EIA 422, EIA 485 2-wire or EIA 485 4-wire) may also be interconnected optically in the Star Configuration. Refer to section 3.5.

#### NOTE

**It is not recommended that a "loop network" be connected to an Optical Star's Slave Port**



**FIGURE 11. Optical Star Configuration  
(OS5 cascaded to an OS5)**

## 2.2 LOOP OPERATION - MASTER/SLAVE CONFIGURATION

### NOTE

Before constructing a loop network, be sure that the software protocol of the Master is capable of managing the receipt of its own echoed transmission. If it cannot, then use either an Optical Bus or Optical Star configuration.

This configuration supports a system which requires more than two IEDs to be communicating. In a Master/Slave loop system, one IED acts as a Master at all times and addresses or "polls" each of the other connected IEDs individually. Each Slave receives the same transmission from the Master IED but only responds when it recognizes its address in the polling message.

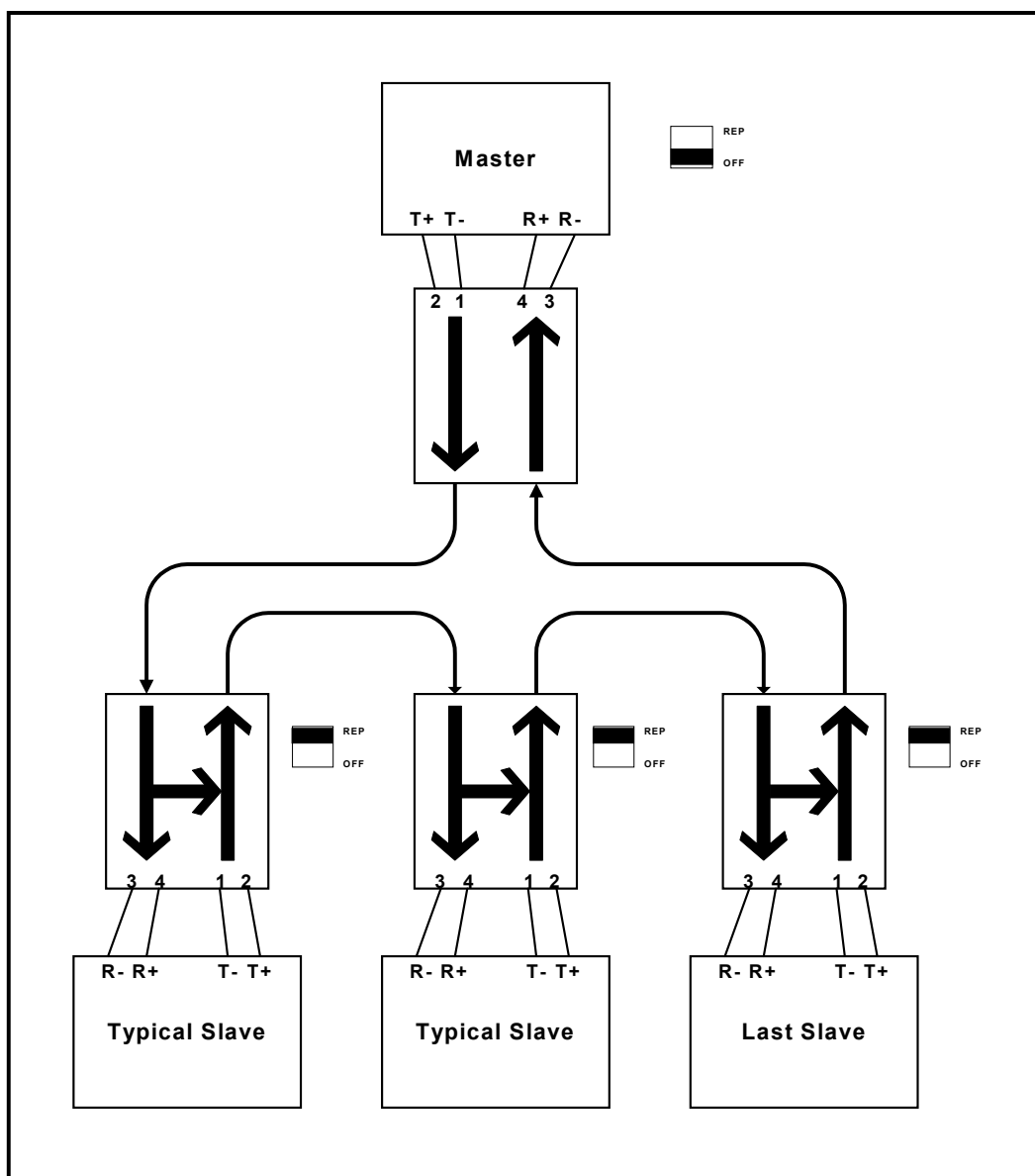


FIGURE 12. Master/Slave Loop Configuration

The Master must have its Mode Jumpers in the "OFF" position. When it transmits a request out its T optical port, it will receive the echo of its request at its R optical port. This request has gone around the loop, and has been repeated by each Slave in the loop. However, the Master does not repeat (re-transmit) any of these received signals optically back around the loop, because its Mode Jumpers are in the "OFF" position.

#### NOTE

**The communication logic and control software of the Master IED must be able to manage the receipt of its echoed request. In the FD Mode, the receipt of the echo can be used in conjunction with a watchdog timer to continuously verify loop integrity.**

When addressed, the Slave will transmit the appropriate response. Each Link/Repeater connected to a Slave IED must have its mode Jumpers set in the "ON" position. In this mode, all signals received on a Slave's R optical port are delivered to the IED's communication port and at the same time repeated out the T optical port to the next device in the loop. If an IED determines that this request requires a response, then the Link/Repeater transmits the IED's response out the T optical port. The response is repeated at each Slave device, until it arrives at the Master.

When an IED is a Slave, it should not attempt to initiate a transmission while it is receiving a signal. Since signals being received are also being repeated at the same time, any attempts to transmit its response while still receiving will corrupt both transmissions due to a data collision.

#### CAUTION

If a Slave IED attempts to transmit while receiving a message, a data collision will occur and both data packets will be corrupted.

In Master/Slave Loop Operation, half duplex communication (sequential transmit and receive functions) is available. Only the Master must communicate full duplex (simultaneous transmit and receive) in a Master/Slave loop, provided its IED has independent Transmit and Receive channels, and the Link/Repeater HD/FD Jumpers is placed in the FD position.

#### CAUTION

If the Master IED operates in half duplex mode, special steps must be taken to control the echo. (Refer to Section 3.6.)

#### APPLICATION NOTE

**In a Master/Slave Loop Operation, the communication logic (control software) and the Master IED must manage:**

- 1) the transmission to Slaves (including addressing).
- 2) the receipt of the echo of its transmissions.
- 3) the receipt of the Slave's response to its transmission.
- 4) the control of the Slaves to prevent the initiation of a transmission while receiving a signal.

### 2.2.1 Installation

1. Set the HD/FD Jumper to the appropriate position for each Link/Repeater and its respective IED.
2. Set the Mode Jumper to "OFF" position on the Master. Set the Mode Jumpers of all the Slave units to the "ON" position.
3. Set the Data Coupling Jumpers for the appropriate position based on the data rate used in the communication network
4. Set the Logic Inversion Jumper to the appropriate position based on the communication network
5. Insert the CH45 into an open slot in the 3900 Chassis and then energize the power source to the 3900 Chassis (See the Installation Sheet for the 3900 Chassis for powering Instructions). The Link/Repeater Card is now powered.
6. Connect the Link/Repeater to the IED's RS-422/485 communication port (including any adapter that may be needed).
7. Connect the Fiber Optic Cables (T of one device to R of the second device).
8. The units are now installed and operating.
9. Verify operation using the diagnostic LEDs. (See Figure 7).

#### **WARNING**

When installing a Model CH45 Link/Repeater, an earth Ground must be attached to the Ground Stud on the rear of the case of the 3900 Chassis before connecting to power. Failure to follow this procedure may result in electrical shock to personnel.

#### **NOTE**

The diagnostic LEDs only illuminate when there is signal traffic and are not illuminated during signal "quiet" times. If during quiet time, TE and TO are illuminated, it suggests either a polarity reversal (pin 2 with pin 1) or that the IED is biased pulling the "A" (+) line with respect to the "B" (-) line. After checking the polarity on the connections, refer to Section 3.5.

The diagnostic LEDs may "flicker" when data is passing. This is normal operation.

### 3. APPLICATIONS

When planning a system using Model CH45 Link/Repeaters, the following considerations should be reviewed:

- Data Rate
- Optical Budget and the distance between connected units
- Number of units in a loop configuration
- Powering the Link/Repeaters
- Type of communication including format
- Selection of Fiber Optic Cable (FOC)

#### 3.1 DATA RATE

Model CH45 Link/Repeater automatically supports all data rates from 1000 bits per second to 2 Megabits per second (with the data coupling jumpers in the factory default settings, or DC to 2 Megabits per second with the data coupling jumpers set to the DC position, see Figure 4 and section 1.2.4). No internal selection nor setting is required. However, it is necessary that all connected IEDs be set at the same data rate.

#### 3.2 OPTICAL BUDGET

The optical budget is a ratio of the receiver sensitivity to launched optical power, i.e. amount of light loss available from the transmitter to the receiver. It is calculated on a log scale so that a 3 dB loss is equal to half of the original power, 10 dB is one tenth of the original power, 20 dB is one hundredth, etc. Many different elements in the optical circuit can induce losses (attenuation) to the power of the signal. This attenuation must be taken into account when determining the distance that the signal can be transmitted. The major factor is the attenuation of the fiber optic cable. Cable attenuation is expressed as "X" dB per kilometer. Other factors of attenuation include FOC fittings (terminations, splitters, etc.) FOC diameter, and FOC aging.

Optical budget is the result of the expression:

$$\frac{\text{Launch Power } [\mu\text{W}]}{\text{Receiver Sensitivity } [\mu\text{W}]}$$

Each Model CH45 Link/Repeater has an available optical budget of 19 dB.

##### 3.2.1 Cable Attenuation Factors

The following cable factors must be applied as corrections to the optical budget.

##### 3.2.1.1 Diameter

###### Multi-mode:

FOC of different diameters will vary the available optical budget of a system due to different FOC core diameters. The 19 dB optical budget is applicable to 62.5  $\mu\text{m}$  diameter FOC. Table 1 shows the correction factors to use on the available optical budget for different diameter cable.

Table 1

FOC DIAMETER	FACTOR
50 $\mu\text{m}$	-3 dB
100 $\mu\text{m}$	+4 dB
200 $\mu\text{m}$	+7 dB

### 3.2.1.2 Fittings

Adding additional splices, feed throughs, or patches to the FOC will add losses to the available optical budget. When using multi-mode Fiber Optic Cable terminated and supplied by DYMEC-DynaStar, optical connector losses can be ignored because the cable is tested after the terminations are added. If you are using fittings not supplied by DYMEC-DynaStar, you can get the optical budget loss information from their manufacturer(s).

### 3.2.1.3 Aging

As FOC ages, tiny cracks will form in the glass core of the fiber. These will cause the attenuation of the cable to increase. The optical emitters age over time causing a reduction in their optical launch power.

DYMEC-DynaStar suggests that a buffer be applied to the optical budget to assure proper operation of the unit over a 20-year life. A 2.5 dB to 3 dB loss factor is suggested to compensate for system aging over 20 years.

#### **EXAMPLE**

*FOC is 62.5/125  $\mu$ m multi-mode (DYMEC-DynaStar supplied)  
100 kpsi rated 3 dB/km and 3 dB for aging  
No other attenuating items in the circuit*

<i>initial:</i>	<i>19 dB Optical Budget</i>
<i>less:</i>	<i>3 dB aging</i>
<i>less:</i>	<i>0 dB for other circuit attenuation fittings</i>
<i>equals:</i>	<i>16 dB</i>
<i>divided by:</i>	<i>3 dB/km</i>
<i>equals:</i>	<i>~5 km maximum distance of FOC between transmitter and receiver</i>

#### **NOTE**

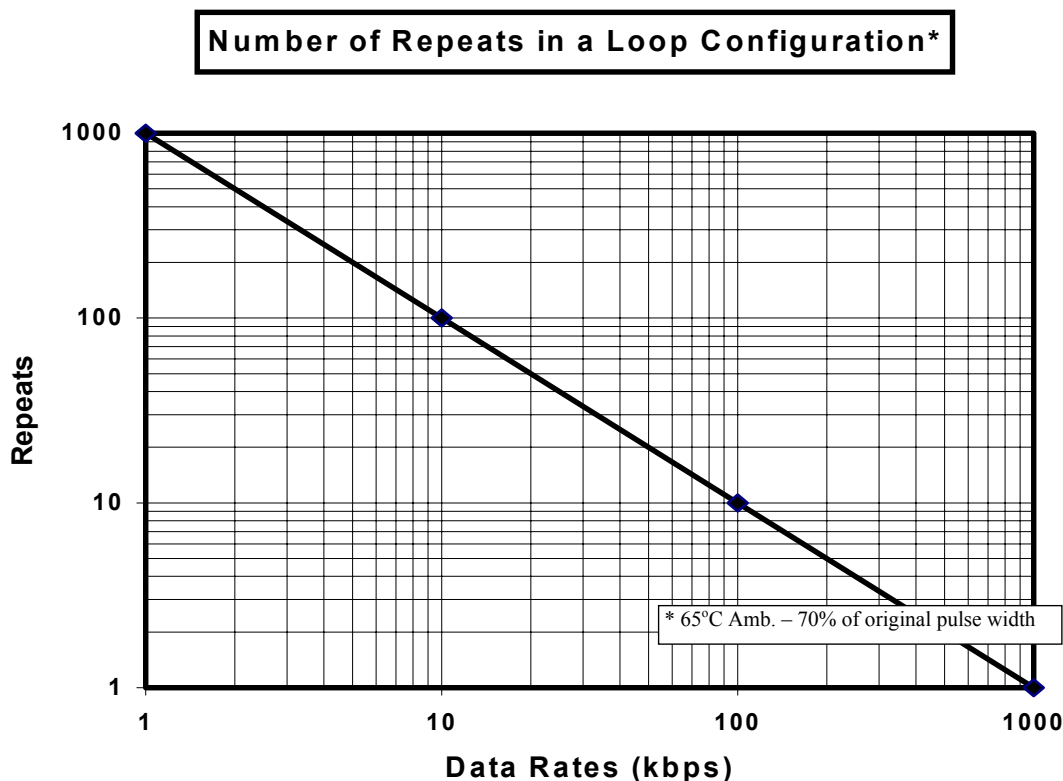
**FOC extends communication beyond normal EIA 422 or 485 Standard limits. The distance allowable between Link/Repeaters must be calculated using the factors listed above.**

### 3.2.2 Extending the Distance

Should the distance between two devices exceed that calculated above, it is possible to insert a pair of Model CH45 or Model 5843 Link/Repeaters to function as stand alone repeaters, powered but not connected to an IED. Two Link/Repeaters are necessary, one for each fiber path. The Repeat Jumpers of each unit is placed in the "ON" position. Serving as a repeater only, the 9 pin D connector should have a protective cover over the pins.

## 3.3 NUMBER OF REPEATS

In a loop configuration, the number of units that can be used as repeaters must be determined. A repeater is any unit that uses the repeat function of the Link/Repeater. All Slaves in a Master/Slave loop are considered repeaters. Three factors must be considered in calculating the maximum number of repeaters possible in a loop; the data rate (bits per second), the minimum required width of the original pulse echoed back to the Master, and the peak operating temperature.



**FIGURE 13. Number of Repeats**

### 3.3.1 Effects of Data Rate

The number of repeaters is an inverse linear function to the data rate (more repeats at lower data rates). The data rate, or bits per second rate, determines what the original pulse width of each bit will be. The higher the data rate, the smaller the pulse width of each bit. As the signal passes through a repeater, any distortion effects on the data signal are greater at higher data rates due to smaller pulse widths than lower data rates.

### 3.3.2 Pulse Width Distortion

As the data signal is passed from repeater to repeater, there is a small change to the pulse width defined as pulse width distortion. The amount of change that is tolerable corresponds to the percentage of original pulse width required by a particular communication system design. Typically, a communication system requires the data word, or bit stream, that each Slave IED receives, match the signal originally generated by the Master, within some tolerance for pulse width distortion. High tolerance systems allow more pulse width distortion, therefore, more repeats are tolerated. Conversely, low tolerance systems allow fewer repeats in the loop.

Figure 13 shows the maximum number of repeats possible if 70% of the original pulse width is required by any IED in the loop. The acceptable percentage of the original pulse width is due to the requirements of the IEDs. If more of the original pulse width is necessary or less is allowable, then the number found in Figure 13 can be modified. Table 2 shows the factors to be used to correct the number of repeats found in Figure 13 for such cases.

% of Original Pulse	Multiply Factor
80%	.67
60%	1.33
50%	1.67

Table 2

### 3.3.3 Temperature Effect

At peak operating temperatures above 65°C, the maximum number of repeats should be de-rated by 20%. At higher temperatures the distortion caused by each repeat increases, causing the maximum number of possible repeaters to go down.

#### **EXAMPLE:**

*Peak temperature of the system will be 70°C  
Running at 9600 bps  
60% of original pulse width possible*

*initial: 100 repeats (from Figure 11)  
less: 20% de-rate for 70°C  
times: 1.33 for 60% pulse width  
equals:  $100 \times 0.8 \times 1.33 = 106$  repeats*

### 3.4 POWERING THE LINK/REPEATER

The Model CH45 is powered through a blade connector when inserted in the DYMEC-DynaStar 3900 15 slot Chassis: The Model CH43 has an internal DC/DC converter that isolates system and earth grounds from signal ground on the DB9 Connector. Care must be taken when cabling not to short these together as the SWC capabilities will be compromised.

### 3.5 LOGIC INVERSION JUMPERS

The Logic Inversion Jumpers are located on the unit (See Figure 1) and are standard on all Model CH45 Link / Repeaters. The Jumpers invert the polarity and logic sense of all electrical transmit and receive signal states going to and from the 9 pin D-connector. It is set in the normal position (factory default). When the Jumper is set to the Invert position, the protocol logic is in the inverted state.

Every CH45 Link/Repeater in the same optical network must have the Logic Inversion Jumper set to the same position so that the quiescent state results in no light in the fiber. This feature is required when optically interconnecting IEDs operating RS-232 to IEDs operating EIA 422 or 485; or connecting to some EIA 422 or 485 IEDs that employ non standard logic to signal communication; or for IEDs that employ line biasing that can cause the light to be on in the quiescent state; and can be used in all configurations.

Model CH45 is designed to operate with no light in the fiber during the communication quiescent (quiet) state. Normal protocol for IEDs operating EIA 422 and 485 format is implemented such that the quiescent state is achieved with the protocol at a logic low producing a potential low output. Occasionally, EIA 422 and 485 may have their output lines biased such that the "A" (+) is pulled high and the "B" (-) line is pulled low in the quiescent state. This situation will produce a "light on" situation in the fiber during the quiescent period. This condition is not desirable and the Logic Jumper must be set in the INVERT position to compensate for this operation.

In addition, one can connect DYMEC-DynaStar Models CH43, 5843 or 5844 (RS-232 Link / Repeaters) to the Models CH45, 5845 or 5846 and achieve RS-232 to EIA 422 or 485 format conversion directly in the fiber connection without the need of external converter devices. However, the following condition must be accounted for. In RS-232, the logic state is inverse to the physical layer, i.e. a logic high produces a physical low. When connecting RS-232 protocol, this logic to physical layer inversion must be reversed or it will cause a “light on” situation in the quiescent state in the Model CH45. Again, the Logic Jumper can be set in the INVERT position to correct this situation.

### **3.6 DATA COUPLING JUMPERS**

The Data Coupling Jumpers are located on the unit (See Figure 1) and is standard on all Model CH45 Link / Repeaters. The Jumper allows the user to select AC or DC input data coupling on the DB9 connector for various network configurations. It is set in the AC position (factory default). When the Jumper is set to the DC position, the input electrical signal is DC coupled to the internal logic.

AC coupling imposes a 1200 baud minimum data rate but in addition decouples any “lock-up” problems on the connected IED from propagating through the network. DC coupling allows DC level signals or baud rates below 1200 to be used but care must be taken in loop networks that the quiescent state of all connected IED’s allow for a light off on the fiber optic side of the CH45. If the IED’s quiescent state leaves the Fiber optic turned on see section 3.5.

### **3.6 BIASING RESISTOR JUMPERS**

The Biasing Resistor Jumpers are located on the unit (See Figure 1) and is standard on all Model CH45 Link / Repeaters. The Jumper allows the user to select 10K Ohm or 300 Ohm biasing resistors on the DB9 connector for various network configurations. It is set in the 330 Ohm position (factory default). When the Jumper is set to the 10K Ohm position, the electrical input loading on the 422/485 bus is reduced.

Biasing resistors are used in 422/485 networks to guarantee valid logic levels are on the bus when the output driver circuitry is in the Tri-State mode. If biasing is not used or available there is a chance that electrical noise on the lines will be misinterpreted as valid data. This is NOT to be confused with termination resistors.

### **3.8 ECHO CONTROL FOR 2 WIRE EIA 485 MASTERS IN LOOP CONFIGURATIONS**

Model CH45 is designed to continuously listen, both electrically and optically, for data signals. Since the path is shared for transmit and receive, only one function may occur at any given interval in time. The Model CH45 is designed to give priority to data signals received optically to those being transmitted electrically assuming that the software logic is managing data traffic.

However, in loop configurations, a special situation occurs if the Master IED is operating 2 wire EIA 485 (HD). The echo of its transmissions can be received back to the Master so fast that it arrives before the transmission is completed and a data collision will occur. Echo control must be implemented for each 2 wire IED that can become a Master in any loop configuration.

### **3.9 TYPE OF COMMUNICATION**

Model CH45 Link/Repeaters support the following types of asynchronous communications:

- Simplex - Transmission only or receive only
- Half Duplex - Sequential transmit and receive
- Full Duplex - Simultaneous transmit and receive

	HD/FD Jumpers in FD Position			HD/FD Jumpers in HD Position		
	Simplex	Half Duplex	Full Duplex	Simplex	Half Duplex	Full Duplex
<b>Point-to-Point:</b> (Mode Jumpers "OFF")	X	X	X	X	X	
<b>Master/Slave Loop:</b> Master (Mode Jumpers "OFF")	X	X	X	X	X	
<b>Master/Slave Loop:</b> Slave (Mode Jumpers "REP")	X	X		X	X	

### 3.10 SELECTION OF FIBER OPTIC CABLE (FOC)

Fiber optical cable is available in several construction types; simplex, duplex, and breakout. FOC is also available in various diameters and tensile strengths.

Simplex FOC is desirable for loop operations. It has one optical conductor and can be connected from the transmitter of one Link/Repeater to the receiver of the next Link/Repeater in the loop.

Duplex FOC has two optical conductors and is a convenient form when connecting two units Point-to-Point.

Breakout cable is a multiple strand FOC that has extra strength members added and is suitable for burial and pulling in conduit. Breakout cable may be ordered with multiple pairs of fiber. For extreme conditions, it is also available with an armor jacket.

Tensile strength is important for longer life expectancy.

The following are the specifications of multi-mode FOC offered by DYMEC-DynaStar and are the recommended minimum standards for optimum performance.

		<b><u>Simplex</u></b>	<b><u>Duplex</u></b>	<b><u>Breakout</u></b>
Fiber Count		1	2	2
Fiber Material		Glass	Glass	Glass
Diameter	[mm]	3.0	3.0 x 6.5	7.0
Weight	[kg/km]	8.0	16.0	50
Tensile load- Short Term	[N]	500	1000	1200
Tensile load- Long Term	[N]	300	500	500
Minimum Bend Radius-With Load	[cm]	5	5	14
Minimum Bend Radius-No Load	[cm]	3	3	7
Crush Resistance	[N/cm]	750	750	2200
Impact Resistance	[Cycles]	1000	1000	2500
Flex Resistance	[Cycles]	7500	7500	2000
Operating Temperature	[°C]	-40° to +85°	-40° to +85°	-40° to +85°
Storage Temperature	[°C]	-55° to +85°	-55° to +85°	-55° to +85°

### **METRIC-TO-ENGLISH UNIT CONVERSIONS**

			<u>MULTIPLY BY</u>				<u>MULTIPLY BY</u>
Millimeters	→	Inches	0.03937	Kilograms	→	Pounds	2.2046
Centimeters	→	Inches	0.3937	Kg/Km	→	Pounds/1,000 Ft	0.67197
Meters	→	Feet	3.2808	Newtons	→	Pounds	0.22481
Kilometers	→	Feet	3280.8	N/Cm	→	Pounds/inch	0.57101
Kilometers	→	Miles	0.62137				

## 4. TESTING AND TROUBLE SHOOTING

### 4.1 TESTING

Model CH45 Link/Repeater is easily tested. Testing the unit requires transmitting and receiving data while observing that the diagnostic LEDs are illuminating in the proper sequence.

To test whether a unit is transmitting and receiving correctly, set the FD/HD Jumpers to the FD position. Insert a short fiber jumper between its "T" and "R" optical ports, power the unit and transmit a signal, noting that all four diagnostic LEDs illuminate during communications.

To test the units in a loop configuration, two Link/Repeaters are required. Connect two short jumper fibers from the "T" optical port of each Link/Repeater to the "R" optical port of the other. Set the Mode Jumpers on one of the units to ON and the other to OFF (Note: the FD/HD Jumpers of this unit must be in the FD position for testing). The unit with the Mode Jumpers in the OFF position is the Master. Power both units. Using the Master, transmit and receive data through the other unit in the repeat mode. Observe the diagnostic LEDs illumination patterns during communication.

#### Note

**If interconnecting EIA 485 optically to RS232, the NORM / INVERT Jumpers must be in the INVERT position.**

**If the IED's design biases A ("+") high and B ("-") low (a "steady" illuminated TE light, with no data flowing, will indicate this), then the NORM / INVERT Jumpers must be set to the INVERT position.**

**If a master of a master/slave loop is operating in the HD mode (EIA 485), refer to Section 3.6 for special system requirements for the control of the echo.**

#### Models CH45

When not connected to an IED and in the repeat mode, the Link/Repeater should have Chassis Ground (pin 9) connected to Signal Common (pin 5). If these pins are not tied together, noise could be induced into the fiber loop. This is also necessary when servicing an IED in order to keep the fiber loop and the Link/Repeater operational.

#### WARNING

The jumper connecting Chassis Ground and Signal Common should be disconnected before reconnecting Model CH45 to an IED.

### TROUBLE SHOOTING

If the unit does not work properly, use the following check list:

1. Is the unit properly powered?
  - a. Verify that the unit is receiving the correct power and the red "PWR" LED is illuminated.
2. Check that the diagnostic LEDs are responding to the optical and electrical activity.
3. Is the unit mated properly to the IED? If an adapter is used, check that pins are connected correctly.
4. Are the fiber cables connected properly? "T" to "R"; not "R" to "R" nor "T" to "T".

5. Are the FD/HD Jumpers, the Repeat Jumpers, and NORM / INVERT Jumpers set to the proper position for the application? (Are all four FD / HD Jumpers set to the same position?)

**NOTE**

**If the Link/Repeater is not connected directly to an IED, determine that the electrical signal received by the Link/Repeater is not corrupt. The Link/Repeater only repeats the signal it is given, it does not re-clock or re-generate the signal.**

6. Review the IED's software and protocols. Does the IED have physical "Handshaking" requirements and have the appropriate settings on the IED been made to compensate for these requirements?
7. Consult factory.

**NOTE**

**The diagnostic LEDs only illuminate when there is signal traffic and are not illuminated during signal "quiet" times. If during quiet time, TE and TO are illuminated, it suggests either a polarity reversal (pin 2 with pin 1) or that the IED is biased pulling the "A" (+) line with respect to the "B" (-) line. After checking the polarity on the connections, refer to Section 3.5.**

**The diagnostic LEDs may "flicker" when data is passing. This is normal operation.**

## 5. SPECIFICATIONS

### Electrical and Optical Specifications (All Specifications over entire Operating Temperature Range)

#### **Models CH45**

#### **LINK:**

I/O Data Format Configuration	EIA 422 or 485 Half/Full Duplex, Jumpers Link/Repeater, Jumpers Input Bias, Jumpers Data Coupling, Jumpers Logic Invert, Jumpers
Electrical Connector	9 pin D-type, female
Data Rate	DC to 2M bps
Data Transmission	Asynchronous, simplex or full/half duplex
Transmission Distance	up to 5000 m (62.5/125µm cable @ 3dB/km)
Bit Error Rate	10E-9 max.
Power Required (Through Optional Power connector)	5 Vdc, 200 mA max.
Operating Temperature	-40°C to +85°C
Storage Temperature	-40°C to +85°C
Point-to-Point Latency Delay	500nS max
Repeat Latency Delay	400nS per Repeat

#### **ELECTRICAL INPUT:**

Input Impedance	750 Ohms
Input Voltage	-7 V to + 12 V max

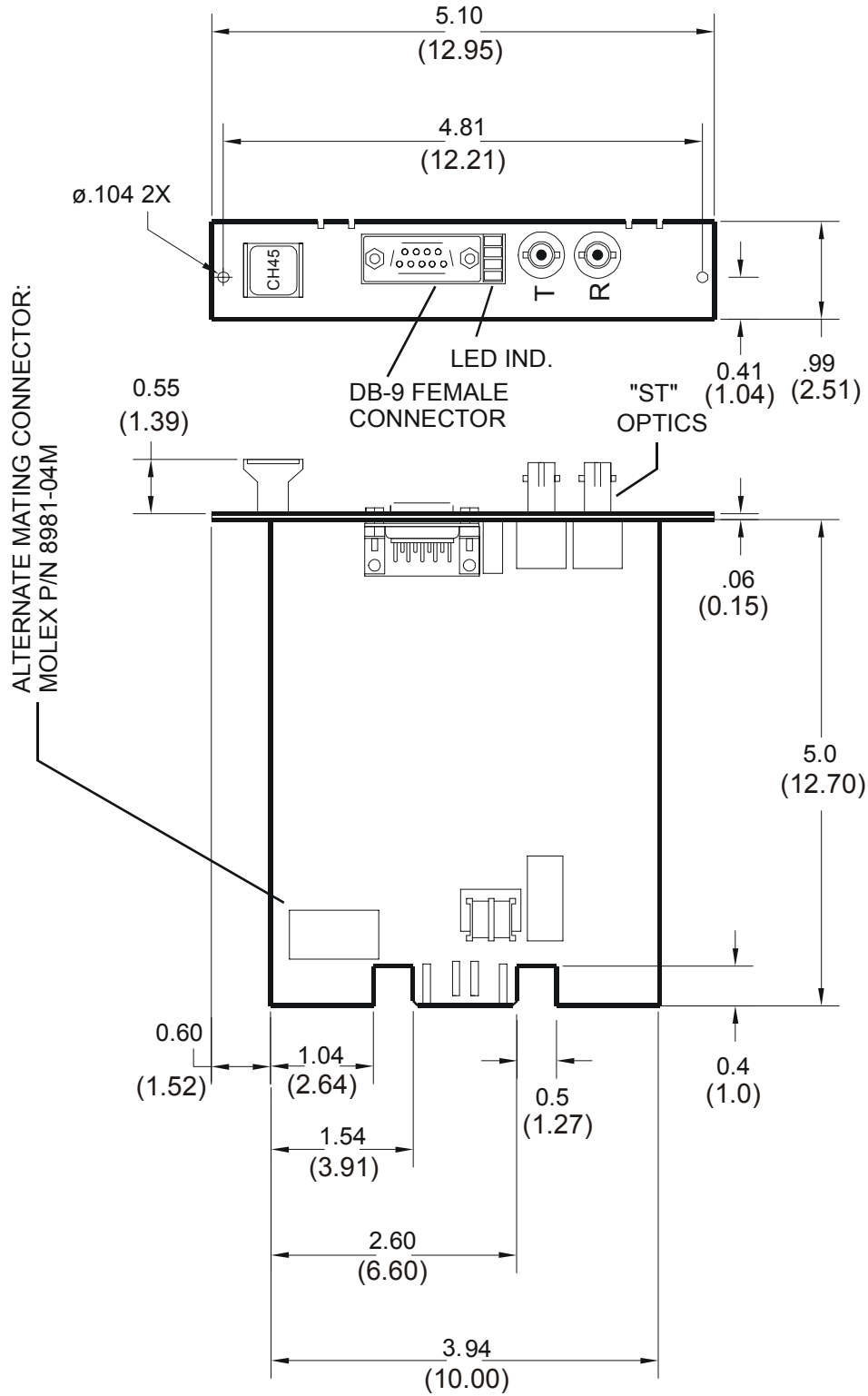
#### **ELECTRICAL OUTPUT:**

Output Impedance	250 Ohms
Driver Output	± 50 mA

#### **OPTICAL INFORMATION:**

Optical Budget	19 dB (62.5/125 µm cable)
Wavelength	850nm
Connector Type	ST
Fiber Type	Multi-mode (50 - 200 µm)
Optical Output	-10.5dBm Typical (62.5 Fiber)
Receiver Sensitivity	-30dBm Typical (62.5 Fiber)

5.2 Mechanical Dimensions of the CH45



DIMENSIONS ARE IN INCHES (CENTIMETER)

## 6.0 Ordering Information:

### LINK/REPEATERS

Part Number			
Model	EIA Std	Fiber Type	Input Power Rating
5843HRT	RS 232/TTL	Multi-Mode	9 - 15 Vdc
5844HRT-H	RS 232/TTL	Multi-Mode	90-250 Vdc/ 90-250 Vac
5844HRT-L	RS 232/TTL	Multi-Mode	24-48 Vdc
CH43	RS 232/TTL	Multi-Mode	+5 Vdc
CH45	RS 422/485	Multi-Mode	+5 Vdc
5846HRT-H	RS 422/485	Multi-Mode	90-250 Vdc/ 90-250 Vac
5846HRT-L	RS 422/485	Multi-Mode	24-48 Vdc
5845HRT	RS 422/485	Multi-Mode	9-15 Vdc
5843SHRT	RS 232/TTL	Single-Mode	9 - 15 Vdc
5844SHRT-H	RS 232/TTL	Single-Mode	90-250 Vdc/ 90-250 Vac
5844SHRT-L	RS 232/TTL	Single-Mode	24-48 Vdc
5845S	RS 422/485	Single-Mode	9 - 15 Vdc
5846SHRT-H	RS 422/485	Single-Mode	90-250 Vdc/ 90-250 Vac
5846SHRT-L	RS 422/485	Single-Mode	24-48 Vdc

### ACCESSORIES

Model	Description
4310	AC to 12 Vdc Power adapter for Models 5843
4310S	AC to 12 Vdc Power adapter for Models 5843S
Bulletin UM5843	User Manual for Models 5843, 5843S, 5844 and 5844S
Bulletin UM5845	User Manual for Models 5845, 5845S, 5846 and 5846S
Bulletin UMCH43	User Manual for Model CH43
Bulletin UMCH45	User Manual for Model CH45
5753A-XXXX	Simplex Multi-Mode Fiber Optic Cable (62.5/125 $\mu$ m), 100 KPSI. Suitable for use in cable troughs, conduit, and outdoor applications.
5754A-XXXX	Duplex Multi-Mode Fiber Optic Cable (62.5/125 $\mu$ m), 100 KPSI. Suitable for use in cable troughs, conduit, and outdoor applications.
5756A-XXXX	Breakout Duplex Multi-Mode Fiber Optic Cable (62.5/125 $\mu$ m), 100 KPSI. Suitable for use in cable troughs, conduit, and outdoor applications and direct burial, underground burial, lashed and building riser.
Terminations	Cable cut to length, Terminated with ST Type Multi-Mode Fiber Optic Connectors and Complete Assembly Tested
ACC-LCS	Mounting Bracket
ACC-CBL1	DB9 Male/ Tinned Lead Pigtail Cable

XXXX = the length of the fiber optic cable in Meters  
 (note: order only in full meters and not a fraction thereof) 1 Meter = 3.281 Feet

## READER'S COMMENTS

We invite your comments and welcome suggestions to make this manual more useful.

Bulletin # \_\_\_\_\_ Rev # \_\_\_\_\_ Today's Date \_\_\_\_\_

### GENERAL COMMENTS:

	Improve	Acceptable	Good	Excellent
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Example/Illustrations	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
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